IMMUNOLOGY

Courses offered by the Immunology Program are listed under the subject code IMMUNOL on the Stanford Bulletin's ExploreCourses web site.

Stanford Immunology is home to faculty, students, postdocs, and staff who work together to produce internationally recognized research in many areas of immunology. The long tradition of collaboration among the immunology laboratories at Stanford fosters productive interdisciplinary research, with an emphasis on the application of current approaches to problems in cellular, molecular and clinical immunology. Faculty research interests include both bench-to-bedside and basic science research. Graduate students and postdoctoral scholars receive outstanding training through their participation in research, teaching, seminars, journal clubs, and the annual Stanford Immunology Scientific Conference.

Mission of the Ph.D. Program in Immunology

The Immunology doctoral program offers instruction and research opportunities leading to a Ph.D. in Immunology. Two tracks are offered:

1. Track 1: Molecular, Cellular, and Translational Immunology
2. Track 2: Computational and Systems Immunology

The goal of the Ph.D. Program in Immunology is to develop investigators who have a strong foundation in Immunology and related sciences in order to carry out innovative research. The program features a flexible choice of courses and seminars combined with extensive research training in the laboratories of participating Immunology faculty. Specifically, immunology graduate students:

1. acquire a fundamental, broad, and comprehensive body of knowledge and skills through an extensive curriculum.
2. identify important scientific questions, design, and conduct experiments using the most appropriate methods.
3. read and critically analyze current literature in immunology and other relevant fields.
4. present research findings and communicate ideas effectively to a variety of audiences.
5. prepare manuscripts that will be published in leading journals.
6. learn to teach effectively.

Master of Science in Immunology

Students in the Ph.D. program in Immunology may apply for an M.S. degree in Immunology only under special circumstances, assuming completion of appropriate requirements. Students must complete:

1. At least 45 units of academic work, all of which must be in courses at or above the 100 level, 36 units of which must be at or above the 200 level.
2. 3 quarters of graduate research (IMMUNOL 399 Graduate Research), consisting of rotations in the labs of three faculty members.
3. Participation in the Immunology journal club (IMMUNOL 305 Immunology Journal Club), and attendance at the Immunology seminar series and at the annual Stanford Immunology Scientific Conference.
4. First Year Rotations Presentations and General Advising Sessions, June. Students present on one of three lab rotations.
5. Students must submit a master's thesis paper on one of their rotations. This requirement may be waived under special circumstances.

Course work in Immunology as follows:

Track: Molecular, Cellular and Translational Immunology

		Units
BIOS 200	Foundations in Experimental Biology	5
BIO 230A	Molecular and Cellular Immunology Literature Review	1
IMMUNOL 201	Advanced Immunology I	3
IMMUNOL 202	Advanced Immunology II	3
IMMUNOL 203	Advanced Immunology III	3
IMMUNOL 311	Seminar in Immunology	1
IMMUNOL 311A	Discussions in Immunology	1
IMMUNOL 305	Immunology Journal Club	1
IMMUNOL 215	Principles of Biological Technologies	3
IMMUNOL 399	Graduate Research	1-15
BIO 141	Biostatistics	3-5
MED 255	The Responsible Conduct of Research	1
Take one of the following courses:		
MI 210	Advanced Pathogenesis of Bacteria, Viruses, and Eukaryotic Parasites	4
BIO 214	Advanced Cell Biology	4
IMMUNOL 206	Introduction to Applied Computational Tools in Immunology	2

Track: Computational and Systems Immunology

		Units
BIOS 200	Foundations in Experimental Biology	5
BIO 230A	Molecular and Cellular Immunology Literature Review	1
IMMUNOL 201	Advanced Immunology I	3
IMMUNOL 202	Advanced Immunology II	3
IMMUNOL 206	Introduction to Applied Computational Tools in Immunology	2
IMMUNOL 207	Essential Methods in Computational and Systems Immunology	3
IMMUNOL 209	Translational Immunology	1
IMMUNOL 310	Seminars in Computational and Systems Immunology	1
BIOMEDIN 212	Introduction to Biomedical Informatics Research Methodology	3
BIOMEDIN 214	Representations and Algorithms for Computational Molecular Biology	3-4
IMMUNOL 399	Graduate Research	1-15
MED 255	The Responsible Conduct of Research	1

Doctor of Philosophy in Immunology

The University's basic requirements for the Ph.D. degree are outlined in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin.

Admissions

Students seeking admissions to the Immunology Ph.D. Program typically have an undergraduate major in biological sciences, but majors from other areas are acceptable if the applicants have sufficient coursework in biology, chemistry, general physics, and mathematics (through calculus). Applications are evaluated by the Immunology Graduate Program committee based upon: GRE scores; grades; evidence of research experience; letters of recommendation, including letters from research sponsor(s); and commitment to a career in biomedical research. The GRE Subject test is not required. Applicants should plan on taking the GRE at least one month prior to the application deadline of December 1 to ensure that official scores are available when applications are

evaluated. Interested Stanford medical students are welcome to apply to the program and should also submit a formal application by December 1.

Prospective graduate students must apply via Stanford's online graduate application.

Financial Aid

Students admitted to the program are offered financial support for tuition, a living stipend, insurance coverage, and for first-year graduate students, a small allowance for books/travel. Applicants are urged to apply for independent fellowships such as from the National Science Foundation or National Defense Science and Engineering Graduate Fellowships. NSF Fellowship applications are due in November of the year prior to matriculation in the graduate program, but Immunology graduate students may continue to apply for outside fellowships after matriculation. Admitted students are typically offered financial support in the form of Stanford Graduate Fellowships, NIH traineeships, or research assistantships.

General Requirements

Immunology Startup and the First-Year Advising Process

Since students enter with differing backgrounds, each student is assisted by the first-year adviser in selecting courses and lab rotations in the first year and in choosing a lab for the dissertation research. In addition, the Immunology Startup, a five-day introduction to immunology in early September, exposes incoming Immunology Ph.D. students to a variety of techniques and concepts. Students learn basic laboratory techniques in immunology and participate in in-depth discussions with faculty.

All students must be enrolled in exactly 10 units during Autumn, Winter, Spring, and Summer quarters until reaching Terminal Graduate Residence (TGR) status in the spring or summer quarter of their fourth year. Students are required to pass all courses in which they are enrolled; required and elective courses must be taken for a letter grade. Students must earn a grade of 'B-' or better in all courses applicable to the degree that are taken for a letter grade. Satisfactory completion of each year's general and track specific requirements listed below is required. During the first year, degree progress is monitored closely by the first-year adviser in quarterly meetings and by the Stanford Graduate Program Committee in a final advising session in June.

First-year students are required to complete three rotations in at least two immunology labs. In the spring quarter, two mini-rotations of six weeks each may be arranged.

A specific program of study for each student is developed individually with the first-year adviser.

Core Courses:

All students in the two tracks, Molecular, Cellular, and Translational Immunology (MCTI) and Computational and Systems Immunology (CSI) are required to enroll in the following core courses:

		Units
BIOS 200	Foundations in Experimental Biology	5
BIO 230A	Molecular and Cellular Immunology Literature Review	1
IMMUNOL 201	Advanced Immunology I	3
IMMUNOL 202	Advanced Immunology II	3
IMMUNOL 305	Immunology Journal Club	1
IMMUNOL 311	Seminar in Immunology	1
IMMUNOL 311A	Discussions in Immunology	1
BIO 141	Biostatistics	3-5
IMMUNOL 399	Graduate Research	1-15
IMMUNOL 290	Teaching in Immunology	1-15
MED 255	The Responsible Conduct of Research	1

In the third week of June, first-year immunology graduate students are required to give a presentation on one of their three rotations to the Immunology Graduate Program Committee (Qualifying Examination Process, Part I). After the rotation presentation, the first-year student will meet with the Stanford Graduate Program Committee in a one-on-one advising session to review degree progress and choice of a PhD thesis lab. The first-year graduate student is asked to complete a "Big Picture" advising document, which takes stock of the first year student's accomplishments in the past year, discusses near- and long-term plans, and serves as a transitional document for the PhD thesis adviser.

The general oral examination and the Ph.D. thesis dissertation proposal constitute part II of the qualifying examination process. The student is required to pass the oral examination and write a thesis dissertation proposal which is presented to and evaluated by a qualifying examination committee composed of three faculty members, two of whom may be from the Immunology program faculty and the third faculty member from a department outside the program. The Ph.D. adviser need not be present for part II, but is required to submit an evaluation and grade for the Ph.D. thesis dissertation proposal. Upon successful completion of part II, the student files a petition for Ph.D. candidacy.

Candidates for Ph.D. degrees at Stanford must satisfactorily complete a program of study that includes 135 units of graduate course work and research. At least 3 units must be taken with each of four different Stanford faculty members. Students in the MCTI track are expected to complete all their core course requirements by the end of their second year; students in the CSI track should complete their course work by the end of the third year.

The dissertation reading committee (generally known as the Ph.D. thesis committee) must be comprised of at least four faculty members who guide the student in the Ph.D. research, and read and approve the final dissertation. Typically three of the four dissertation reading committee members are from the Immunology program faculty.

The student must meet with the dissertation reading committee at least once a year. In the first through third years, the student must meet with the dissertation committee at least once a year. In the fourth and fifth years, the student is expected to meet twice a year with the Ph.D. thesis committee. For students in their fifth years and above, a member of the Immunology graduate program committee also attends these bi-annual thesis committee meetings. In addition, a secondary adviser is assigned who can provide additional advice on issues such as career path choices and other non-academic issues.

Individual Development Plan: Graduate students are required to meet with their faculty mentors once a year to discuss an individual development plan" (IDP). The IDP is intended to help the students take ownership of their training and professional development. The goals of the IDP are to: 1) pause, reflect and intentionally think on short-, mid- and long-term goals; 2) identify resources that help to achieve these goals; and 3) have open and direct dialogue with the Ph.D. thesis adviser and establish clear expectations and steps.

Track Specific Requirements

In addition to the general requirements listed above, students must also complete requirements within their track. Written petitions for exemptions to core curriculum and lab rotation requirements are considered only in the first year by the advising committee and the chair of the Graduate Program committee. Approval is contingent upon special circumstances and is not routinely granted.

Molecular, Cellular, and Translational Immunology

MCTI first-year students are required to take the following courses in their first year for a letter grade:

		Units
IMMUNOL 203	Advanced Immunology III	3
IMMUNOL 215	Principles of Biological Technologies	3
Take one of the following courses:		
MI 210	Advanced Pathogenesis of Bacteria, Viruses, and Eukaryotic Parasites	4
BIO 214	Advanced Cell Biology	4
IMMUNOL 206	Introduction to Applied Computational Tools in Immunology	2

Electives:

One elective (see elective list below)

		Units
IMMUNOL 275	Tumor Immunology	2
CSB 210	Cell Signaling	4
SBIO 241	Biological Macromolecules	3-5
DBIO 210	Developmental Biology	4
CBIO 240	Molecular Genetic Basis of Cancer	4

Computational and Systems Immunology

The CSI curriculum trains students to be computational and experimental scientists, who are expected to identify important problems in immunology and to devise integrated computational/ experimental plans for addressing them.

CSI students are required to take the following courses in their first and second years.

First Year:

		Units
CS 106A	Programming Methodology	3-5
CS 109	Introduction to Probability for Computer Scientists	3-5
CS 161	Design and Analysis of Algorithms	3-5
IMMUNOL 206	Introduction to Applied Computational Tools in Immunology	1-2
IMMUNOL 207	Essential Methods in Computational and Systems Immunology	3
IMMUNOL 310	Seminars in Computational and Systems Immunology	1
BIOMEDIN 212	Introduction to Biomedical Informatics Research Methodology	3
BIOMEDIN 217	Translational Bioinformatics	4

Second Year:

		Units
IMMUNOL 207	Essential Methods in Computational and Systems Immunology	3
IMMUNOL 208	Advanced Computational and Systems Immunology	3
STATS 216	Introduction to Statistical Learning	3
BIOMEDIN 214	Representations and Algorithms for Computational Molecular Biology	3-4

Electives:

Two electives (see elective list below)

		Units
STATS 116	Theory of Probability	3-5
CME 206	Introduction to Numerical Methods for Engineering	3
CME 263	Introduction to Linear Dynamical Systems	3
CME 309	Randomized Algorithms and Probabilistic Analysis	3
CME 334	Advanced Methods in Numerical Optimization	3
BIOMEDIN 260	Computational Methods for Biomedical Image Analysis and Interpretation	3-4
BIOMEDIN 262	Computational Genomics	3
BIOMEDIN 374	Algorithms in Biology	2-3
STATS 201	Design and Analysis of Experiments	3-5
STATS 202	Data Mining and Analysis	3
STATS 217	Introduction to Stochastic Processes I	2-3
EE 376A	Information Theory	3
CME 364A	Convex Optimization I	3
CME 372	Applied Fourier Analysis and Elements of Modern Signal Processing	3
EE 278	Introduction to Statistical Signal Processing	3
EE 378A	Statistical Signal Processing	3
Other		

Journal Clubs

Both MCTI and CSI students are required to attend the IMMUNOL 305 Immunology Journal Club for their first through third years. Attendance is optional for fourth year and above graduate students.

Immunology and CSI Seminar Series

Graduate seminars are an important means of attaining a broad and comprehensive exposure to all areas in immunology as well as gaining a professional perspective and competence in the field. First-year students are required to attend all immunology seminars (IMMUNOL 311 Seminar in Immunology) and the companion immunology seminar discussions course (IMMUNOL 311A Discussions in Immunology); in the latter, the seminar speakers' papers are discussed. Students in their second year and above are required to attend 50% of the seminar series each academic year. Students in the CSI track are required to attend the Computational and Systems Immunology Seminar Series (IMMUNOL 310 Seminars in Computational and Systems Immunology) held every Summer Quarter.

Immunology Scientific Retreat

The annual Retreat is held at the Asilomar Conference Grounds, Pacific Grove, CA, and is attended by students, staff, postdocs and faculty of the Stanford immunology community. All immunology graduate students are required to attend. In the third through fifth years, students will present a poster and give a talk on their graduate research.

Teaching Assistantships

Teaching experience and training are part of the graduate curriculum. Each student assists in teaching two courses in the immunology core or electives. A TA match process is held in summer quarter in order to match the graduate student's research and teaching preferences to the appropriate courses. Before beginning their assigned teaching assistantships, students are required to attend a TA orientation workshop held by VPTL once a year in late September.

First Author Paper Submission

By the fourth or fifth year, graduate students are expected to submit a first author paper for publication. This milestone should be completed before defending a Ph.D. thesis.

Doctoral Dissertation

Before embarking on the dissertation defense process, the graduate student must submit a Petition to Defend to the Chair of the Immunology Graduate Program. Important milestones and degree requirements must be met before proceeding to the oral examination. A substantial draft of the dissertation must be turned in to the student's oral examination committee at least one month before the oral exam is scheduled to take place. At the time of the Ph.D. orals defense, an orals chair is

chosen to lead the orals committee, which is a distinct committee, but the basic membership is identical to that of the dissertation reading committee. The minimum number of faculty committee members for the orals committee is five. The final written dissertation must be approved by the student's reading committee and submitted to the Registrar's Office. Upon completion of this final requirement, a student is eligible for conferral of the Ph.D. degree.

Faculty

Director, Executive Committee for the Immunology Program: Patricia Jones (Professor, Biology)

Chair for Immunology Graduate Program: Olivia Martinez (Professor, Research, Surgery, Transplantation)

Participating Departments and Faculty (Molecular, Cellular, Translational Immunology)

Biochemistry: Peter Kim (Professor), Lingyin Li (Assistant Professor)

Bioengineering: Stephen Quake (Professor, and Applied Physics and Physics)

Biology: Patricia P. Jones (Professor)

Genetics: Leonore A. Herzenberg (Professor, Research), Karla Kirkegaard (Professor), Michael Snyder (Professor)

Medicine/Biomedical Informatics: Purvesh Khatri (Assistant Professor)

Medicine/Blood and Bone Marrow Transplantation Program: Everett Meyer (Assistant Professor), David Miklos (Associate Professor), Robert Negrin (Professor), Judith Shizuru (Professor)

Medicine/Cardiovascular Medicine: Joseph Wu (Professor, and Radiology)

Medicine/Endocrinology: Joy Wu (Assistant Professor)

Medicine/Gastroenterology and Hepatology: Aida Habtezion (Assistant Professor)

Medicine/Hematology: Ravi Majeti (Associate Professor)

Medicine/Immunology and Rheumatology: C. Garrison Fathman (Professor), Jorg Goronzy (Professor), William Robinson (Associate Professor), Samuel Strober (Professor), Paul J. Utz (Professor), Cornelia Weyand (Professor)

Medicine/Infectious Diseases: Catherine Blish (Assistant Professor), Paul Bollyky (Assistant Professor)

Medicine/Oncology: Ash Alizadeh (Associate Professor), Gilbert Chu (Professor, and Biochemistry), Dean Felsher (Professor, and Pathology), Ronald Levy (Professor), Shoshana Levy (Professor, Research)

Medicine/Nephrology: Jonathan Maltzman (Associate Professor)

Medicine/Pulmonary and Critical Care Medicine: Mark Nicolls (Professor)

Microbiology and Immunology: John Boothroyd (Professor), Yueh-Hsiu Chien (Professor), Mark M. Davis (Professor, and Director, Institute for Immunity, Transplantation and Infection), Juliana Idoyaga (Assistant Professor), Holden Maecker (Associate Professor, Research), Hugh McDevitt (Professor, Emeritus), Denise Monack (Professor), Garry P. Nolan (Professor), David Schneider (Associate Professor)

Molecular and Cellular Physiology: K. Christopher Garcia (Professor, and Structural Biology), Richard S. Lewis (Professor)

Neurology and Neurological Sciences: May Han (Assistant Professor), Lawrence Steinman (Professor, and Pediatrics), Tony Wyss-Coray (Professor)

Neurosurgery: Theo Palmer (Associate Professor)

Otolaryngology/Head and Neck Surgery (ENT): Jayakar Nayak (Assistant Professor), John B. Sunwoo (AssociateProfessor)

Pathology: Robert Michael Angelo (Assistant Professor), Sean Bendall (Assistant Professor), Scott Boyd (Assistant Professor), Eugene C. Butcher (Professor), Michael Cleary (Professor), Gerald R. Crabtree (Professor, and Developmental Biology), Edgar G. Engleman (Professor, and Medicine/Immunology and Rheumatology), Andrew Fire (Professor, and Genetics), Stephen Galli (Professor), Sara Michie (Professor), Raymond A. Sobel (Professor), Irving Weissman (Professor, and Director, Stem Cell and Regenerative Medicine Institute, and of Developmental Biology, Biology)

Pediatrics: Manish Butte (Assistant Professor), Christopher Contag (Professor, Research, and Microbiology and Immunology, and Radiology), David B. Lewis (Professor), Crystal Mackall (Professor), Maria Grazia Roncarolo (Professor, and Medicine/Blood and Marrow Transplantation), Elizabeth Mellins (Professor), Kari Nadeau (Professor)

Psychiatry and Behavioral Sciences: Firdaus Dhabhar (Associate Professor), Emmanuel Mignot (Professor)

Radiology: Parag Mallick (Assistant Professor and Diagnostic Radiology)

Structural Biology: Peter Parham (Professor, and Microbiology and Immunology), Theodore Jardetzky (Professor)

Surgery/Multi-Organ Transplantation: Sheri Krams (Associate Professor, Research), Olivia Martinez (Professor, Research)

Participating Departments and Faculty (Computational and Systems Immunology)

Bioengineering: Stephen Quake (Professor, and Applied Physics and Physics)

Genetics: Michael Snyder (Professor), Karla Kirkegaard (Professor)

Med/Biomedical Informatics: Purvesh Khatri (Assistant Professor)

Med/Immunology and Rheumatology: Paul J. Utz (Professor)

Med/Oncology: Ash Alizadeh (Assistant Professor)

Microbiology and Immunology: John Boothroyd (Professor), Mark M. Davis (Professor, and Director, Institute for Immunity, Transplantation and Infection), Holden Maecker (Associate Professor, Research), Garry Nolan (Professor)

Pathology: Sean Bendall (Assistant Professor), Scott Boyd (Assistant Professor), Andrew Fire (Professor, and Genetics)

Radiology: Parag Mallick (Assistant Professor, and General Radiology)

Affiliate Members:

Biochemistry: Ron Davis (Professor, and Genetics)

Bioengineering: Russ Altman (Professor, and Genetics and Computer Science)

Health and Research Policy - Biostatistics: Robert Tibshirani (Professor, and Statistics)

Courses

IMMUNOL 199. Undergraduate Research. 1-18 Unit.
Presentations and discussions focus on how current research has progressed from the classic findings in Immunology. This third course in the Immunology core curriculum develops effective presentation skills that are appropriate for a given audience and situation. Students will gain experience in developing and presenting chalk talks, formal presentations, and the all-important elevator pitch on current research. Students will benefit from peer, TA and instructor feedback on all presentations.

IMMUNOL 201. Advanced Immunology I. 3 Units.
For graduate students, medical students and undergraduates. Topics include the innate and adaptive immune systems; genetics and function of immune cells and molecules; lymphocyte activation and regulation of immune responses. Recommended: undergraduate course in immunology.
Same as: MI 211

IMMUNOL 202. Advanced Immunology II. 3 Units.
Readings of immunological literature. Classic problems and emerging areas based on primary literature. Student and faculty presentations. Prerequisite: IMMUNOL 201/MI 211.
Same as: MCP 202

IMMUNOL 203. Advanced Immunology III. 3 Units.
Key experiments and papers in immunology. Course focuses on the history of Immunology and how current research fits into the historical context. Students work on developing effective presentation skills.

IMMUNOL 204. Innate Immunology. 3 Units.
Innate immune mechanisms as the only defenses used by the majority of multicellular organisms. Topics include Toll signaling, NK cells, complement, antimicrobial peptides, phagocytes, neuroimmunity, community responses to infection, and the role of native flora in immunity. How microbes induce and defeat innate immune reactions, including examples from vertebrates, invertebrates, and plants.
Same as: MI 104, MI 204

IMMUNOL 205. Immunology in Health and Disease. 4 Units.
Concepts and application of adaptive and innate immunology and the role of the immune system in human diseases. Case presentations of diseases including autoimmune diseases, infectious disease and vaccination, hematopoietic and solid organ transplantation, genetic and acquired immunodeficiencies, hypersensitivity reactions, and allergic diseases. Problem sets based on lectures and current clinical literature. Laboratory in acute and chronic inflammation.

IMMUNOL 206. Introduction to Applied Computational Tools in Immunology. 1-2 Unit.
Introduction to computational tools for analyses of immunological data sets, including but not limited to single-cell data such as that from flow cytometry of CyTOF, as well as genomic anlayses. Students become familiar with major web-based databases and analysis suites for immunological and genomic data; gain a working knowledge of the major software/algorithms for working with major data types, and be able to apply at least one computational tool in these areas to analyze a public data set. Students taking the course for 2 units will complete a computational analysis project and present it to the class.

IMMUNOL 206B. Directed Projects in Systems and Computational Immunology. 3-10 Units.
Independent and team grant proposals, developed in Immunol 206A, will continue on as projects and contribute to ongoing research. Number of units assigned dependent upon the difficulty of and time spent on the project. May be repeated for credit.

IMMUNOL 207. Essential Methods in Computational and Systems Immunology. 3 Units.
Introduction to the major underpinnings of systems immunology: first principles of development of computational approaches to immunological questions and research; details of the algorithms and statistical principles underlying commonly used tools; aspects of study design and analysis of data sets. Prerequisites: CS106a and CS161 strongly recommended.

IMMUNOL 208. Advanced Computational and Systems Immunology. 3 Units.
Focus is on first principles and methods of advanced computational and systems immunology that are used in the analysis of protein and nucleic acid sequences, protein structures, and immunological processes. Students learn to write computational algorithms for sequence alignment, motif finding, expression array analysis, structural modeling, structure design and prediction, and network analysis and modeling. Students become familiar with the technologies used in CSI, which include dynamic programming, Markov and hidden Markov models, Bayesian networks, clustering methods, and energy minimization approaches. Designed for students with strong foundations in either immunology or computer science . Prerequisites: Immunol 207, CS 109 and CS 161.

IMMUNOL 209. Translational Immunology. 1 Unit.
(Open to medical students in the Immunology concentration, graduate students, undergraduates by consent of instructor) Journal style format focusing on current basic immunology research and how it is translated into immunotherapies and clinical trials. Topics include hematopoiesis, transplantation, tolerance, immune monitoring, vaccination, autoimmunity and antibodies, rheumatoid arthritis, chronic pulmonary disease, and asthma. May be repeated for credit.

IMMUNOL 210. Immunology Research Seminars for Medical Students. 2 Units.
Required for medical students selecting the Immunology Concentration. Attendance at a minimum of ten seminars related to immunology outside of required medical school classes. A one-page essay on each seminar, what was presented and how it relates to a clinical immunologic problem, is required.

IMMUNOL 215. Principles of Biological Technologies. 3 Units.
The principles underlying novel as well as commonly utilized techniques to answer biological questions. Lectures and primary literature critiques on topics such as fluorescence microscopy, including applications such as FRET and single-cell analysis; human and murine genetic analysis; FACS; proteomics and analysis of noncoding RNAs. Class participation is emphasized. Prerequisite: biochemistry. Required of first-year graduate students in Microbiology and Immunology and the Immunology program.
Same as: MI 215

IMMUNOL 260. HIV: The Virus, the Disease, the Research. 3-4 Units.
Open to medical students, graduate students in biological sciences, undergraduates with strong biological background. Topics: immunopathogenesis immune deficits, opportunistic infections including TB, and malignancies; genomics viral genetic analyses that have traced the origin of HIV-1 and HIV-2 to primates, dated the spread of infection in humans, and characterized the evolution of the virus within infected individuals; antiretroviral drug development identification of drug targets, structure-based drug design, overcoming drug resistance, pivotal clinical trials, and role of community activism; clinical management solutions in high- and low-income countries; vaccine development learning from past failures and the future of engineering the human immune response. 4 units includes a final project assigned in consultation with the instructor to fit the individual student's background and area of HIV interest.
Same as: MED 260

IMMUNOL 275. Tumor Immunology. 2 Units.
Tumor Immunology focuses on the mechanisms by which tumors can escape from and subvert the immune system and conversely on the ability of innate and adaptive arms of the immune system to recognize and eliminate tumors. Topics include: tumor antigens, tumor immunosurveillance and immunoediting, tumor immunotherapy (including CAR-T and checkpoint antibodies) and cancer vaccines. Tracks the historical development of our understanding of modulating tumor immune response and discusses their relative significance in the light of current reserach findings. Prerequisite: for undergraduates, human biology or biology core.
Same as: CBIO 275

IMMUNOL 280. Early Clinical Experience in Immunology. 1-3 Unit.
Clinical observation experience for medical students in the Immunology Scholarly Concentration. At the end of the observation period, which may span over one to two quarters, the student submits a case observation paper to his/her faculty sponsor. Prerequisite: IMMUNOL 205.

IMMUNOL 286. Neuroimmunity. 2-3 Units.
Focus is on the homeostatic and pathogenic interactions between the immune and central nervous system. Topics include the role of immune cells and inflammatory mediators in the physiological functions, neural development, neuroexcitation, and the pathogenic impact of inflammatory responses. Prerequisite of Molecular and Cellular Immunology (Bio 230) or Advanced Immunology (Immunol 201). Otherwise, request permission from the course director to enroll.

IMMUNOL 290. Teaching in Immunology. 1-18 Unit.
Practical experience in teaching by serving as a teaching assistant in an immunology course. Unit values are allotted individually to reflect the level of teaching responsibility assigned to the student. May be repeated for credit.

IMMUNOL 299. Directed Reading in Immunology. 1-18 Unit.
Prerequisite: consent of instructor.

IMMUNOL 305. Immunology Journal Club. 1 Unit.
Required of first- to third-year graduate students. Graduate students present and discuss recent papers in the literature. May be repeated for credit.

IMMUNOL 310. Seminars in Computational and Systems Immunology. 1 Unit.
Presentation of CSI technologies from recent literature. Discussion of emerging application areas and limitations. Dissemination of computational resources.

IMMUNOL 311. Seminar in Immunology. 1 Unit.
Enrollment limited to Ph.D., M.D./Ph.D., and medical students whose scholarly concentrations are in Immunology. Current research topics.

IMMUNOL 311A. Discussions in Immunology. 1 Unit.
Students discuss papers of speakers in 311, and meet with the speakers. Corequisite: 311.

IMMUNOL 315. Special Topics in Immunology. 1 Unit.
Directed readings and survey study of these topics in human and mousenimmunology: cells of the immune system; innate and adaptive immunity; antibodies and antigens; histocompatibility complex; lymphocyte development and the rearrangement and expression of antigen receptor genes; T-cell and B-cell signaling and activation; immunological tolerance; transplantation; diseases caused by immune responses; allergy; congenital and acquired immunodeficiencies. Graduate students outside immunology and Postdoctoral fellows and clinical fellows are welcome.

IMMUNOL 399. Graduate Research. 1-18 Unit.
For Ph.D., M.D./Ph.D. students, and medical students whose scholarly concentrations are in Immunology.

IMMUNOL 801. TGR Project. 0 Units.
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IMMUNOL 802. TGR Dissertation. 0 Units.
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